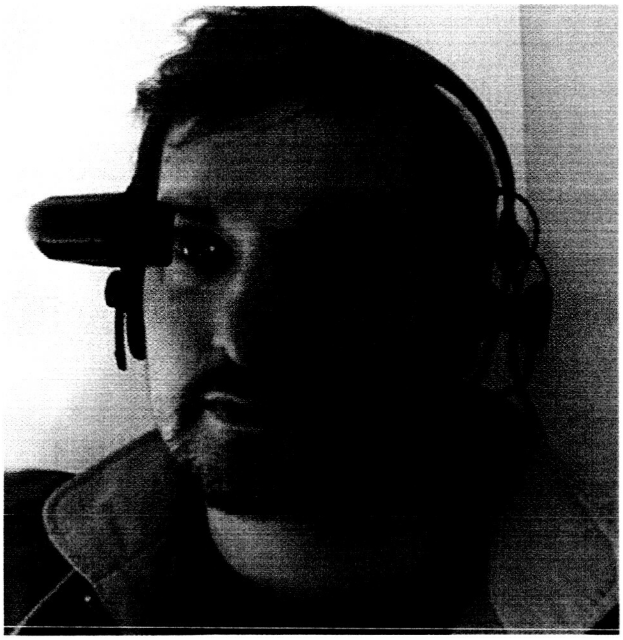

Fig. 2. A near-to-eye display system in use.

Point of Contact: J. O. Larimer
(650) 604-5185
jlarimer@mail.arc.nasa.gov

Human Factors Field Evaluation of Cockpit Display of Traffic Information (CDTI)

Rose Ashford, Vernol Battiste

Cockpit Display of Traffic Information (CDTI) is a major departure from traditional ground-based air traffic control and will markedly improve air traffic safety and efficiency, as well as facilitate modernization of the National Airspace System. A prototype CDTI was installed on 12 aircraft (8 Boeing 727's and 4 DC-9's) belonging to the member airlines of the Cargo Airline Association. This initial CDTI (figure 1) displays proximate aircraft relative to their own-ship, assisting flight crews in sighting and identifying traffic "out the window." NASA provided a human factors evaluation of the CDTI to demonstrate whether it would be safe and effective for these initial visual applications, and to provide preliminary results supporting future CDTI applications involving aircraft that are sharing separation responsibility.

Flight scenarios were developed to evaluate flight crew workload, situational awareness, and effectiveness of the CDTI as an aid to visual acquisition and visual approaches. Additional scenarios were developed to demonstrate aircraft station-keeping capabilities assisted by the CDTI. A data collection program was developed and implemented, including the recruiting and training of NASA observers for each flight, and developing protocols for collecting data from the flight deck during the flight scenarios, and for debriefing the flight crews afterward. The evaluation focused on examining the CDTI's effects on flight crew workload and attention, and how normal cockpit procedures were affected by its use.

The planned flight scenarios were flown at Airborne Airpark in Wilmington, Ohio, on July 10, 1999. Results from the evaluation indicate that the CDTI provides significant benefits in flight crew situational awareness, that it aids visual acquisition of traffic, and that it enhances visual approaches. Flight crews found the CDTI easy to use, and they were very positive regarding CDTI as an aid to visually acquiring traffic and determining how close to follow when making a visual approach to a runway. They thought the CDTI helped them maintain awareness of several targets and to reacquire previously sighted traffic, both common requirements in busy terminal airspace. Analysis of the aircraft track data also indicates that the CDTI enhances approach efficiency, although there is much variability in those data, a direct result of the real flight environment. Flight crews were able to manage the station-keeping task satisfactorily.

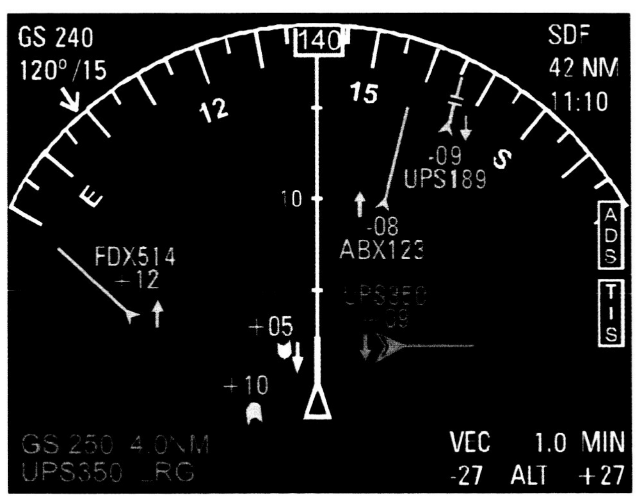

Fig. 1. Cockpit display of traffic information.

The results of this investigation are being used to support further development of the CDTI and its eventual installation in many more aircraft. Additionally, evaluation of this prototype is contributing to future CDTI designs and their applications toward free-flight for all aircraft. This has significant implications for future aviation capacity and safety enhancements, and supports the Aerospace Technologies Enterprise goal of tripling throughput while maintaining safety in the National Airspace System.

Point of Contact: R. Ashford
(650) 604-0914
rashford@mail.arc.nasa.gov

Rotorcraft Uninhabited Aerial Vehicle (RUAV) System Identification, Modeling, and Flight Control System Development

Mark B. Tischler, Luigi S. Cicolani, Jason D. Colbourne, Chad R. Frost

A new challenge to industry and the government alike is the trend toward highly compressed schedules for rotorcraft uninhabited aerial vehicle (RUAV) development and system fielding. Current RUAV proposals and development programs are on 6- to 9-month schedules, in contrast to the 6- to 10-year schedules common to most recent piloted rotorcraft systems. This year, the Army/NASA Rotorcraft Division launched a new initiative: COntrol and Simulation Technologies for Autonomous Rotorcraft (COSTAR) which seeks to develop key enabling technologies for the control and simulation of RUAVs.

The COSTAR initiative refines technologies originally developed for manned rotorcraft for application to the RUAV problem, and seeks to increase technology integration sufficiently to realize the desired reduction in design cycle time. Key elements of COSTAR include accurate flight-mechanics modeling using system identification (CIFER®), control system design optimization for multiple objectives (CONDUIT), and real-time workstation-based simulation (RIPTIDE). COSTAR technologies are central to three ongoing cooperative projects, in which university and industry RUAV developers have teamed with the Army/NASA Rotorcraft Division's Flight Control Technology Group.

In one such cooperative activity, Army/NASA personnel worked under direct contract to Northrop Grumman, supporting development of the U.S. Navy's Vertical Takeoff UAV (VTUAV) (figure 1). Ames personnel participated in flight testing, followed by extensive system identification of the aircraft dynamic models (using CIFER®), and flight control analysis/optimization (using CONDUIT). Ames was also responsible for developing the detailed flight control preliminary design, including the determination of a comprehensive set of "Aeronautical Design Standard-33 (ADS-33) like" design requirements for use in CONDUIT. This close working relationship resulted in a successful autonomous flight of the demonstrator aircraft. The Flight Control Technology Group is currently under contract to Northrop Grumman to support system identification of forward flight models, and flight control law optimization for the full flight envelope.

Another joint venture involves model identification, control system design, and flight testing of a fully instrumented model-scale unmanned helicopter (a Yamaha R-50 with 10-foot-diameter rotor). In conjunction with Carnegie-Mellon University, the CIFER® system identification techniques developed for full-size helicopters were applied to the R-50. An accurate, high-bandwidth, linear state-space model was derived for the hover condition. A conclusion of this study was that small helicopters seem to be particularly well suited to identification, in part because of the dominance of the rotor in their dynamics. This is illustrated by the exceptionally clean frequency-sweep time responses shown in figure 2. The R-50 was shown to be dynamically similar to a scaled UH-1H, although the R-50 is proportionally heavier. Preliminary control system designs have been studied using CONDUIT, and evaluated using the RIPTIDE simulation environment for remotely piloted operations.

Army/NASA personnel and technology have also been instrumental in Kaman Aerospace's development of the Broad-area Unmanned Responsive Resupply Operations (BURRO) aircraft for the U.S. Marine Corps. The BURRO program adapts the existing K-MAX piloted external-lift helicopter for